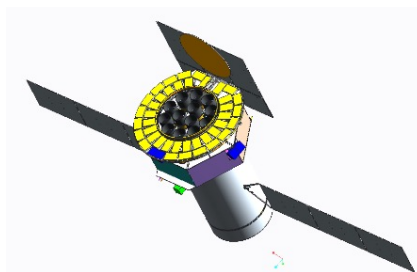


Plans of IHEP

Yifang Wang

Institute of High Energy Physics, Beijing

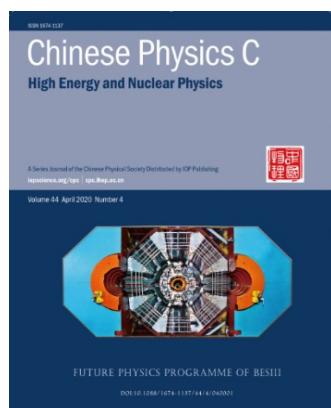
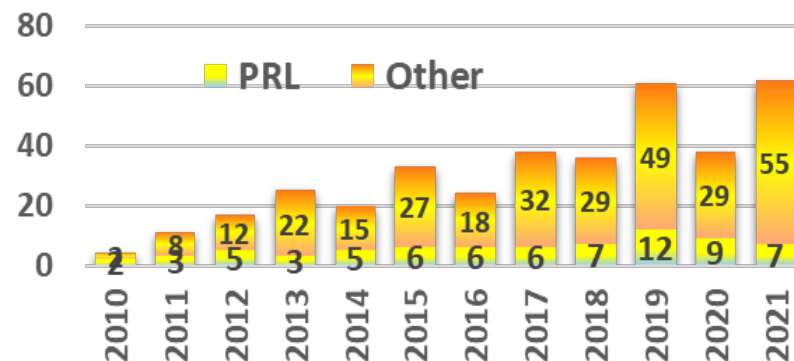
Snowmass, July 25, 2022



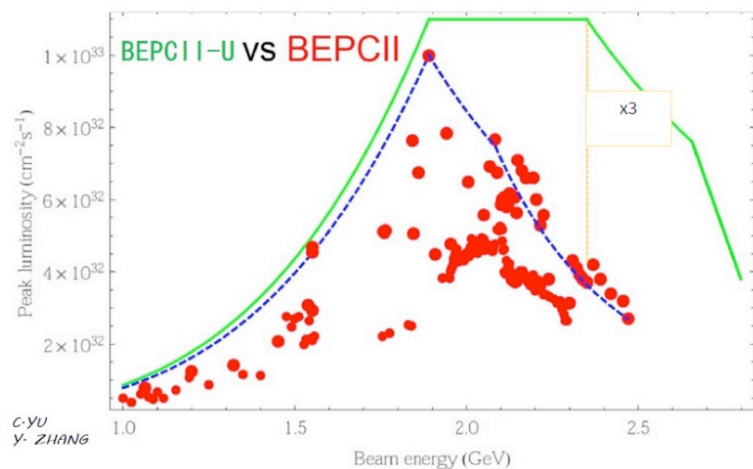
BEPCII/BESIII: 2009-2030

- Fruitful physics results
- Rich physics program requiring $> 40 \text{ fb}^{-1}$, corresponding to $\sim 15 \text{ yrs@curr. lumi.}$
- Upgrade to be completed in 2024:
 - Luminosity $\times \sim 3 \rightarrow$ squeeze the beam size by adding a new RF cavity per beam
 - Replace the two SC quadrupole magnets near the IP to increase the maximum beam energy from 2.45 to 2.8 GeV \rightarrow for charmed baryons

BESIII Publications

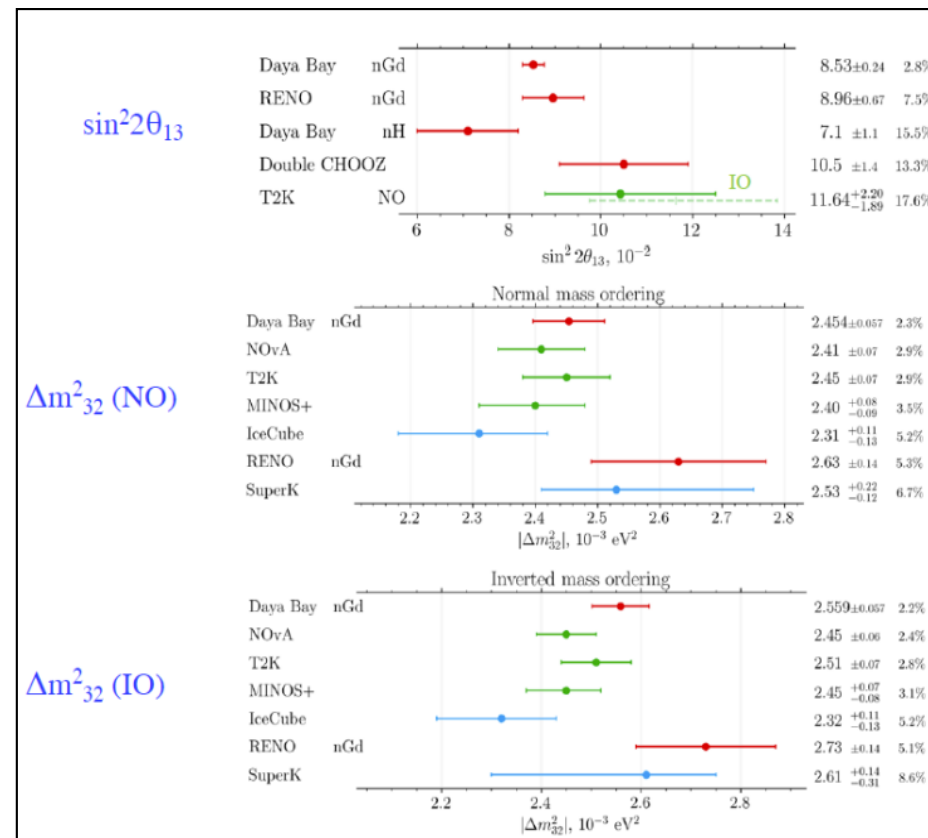


Future physics program of BESIII



Daya Bay Experiment

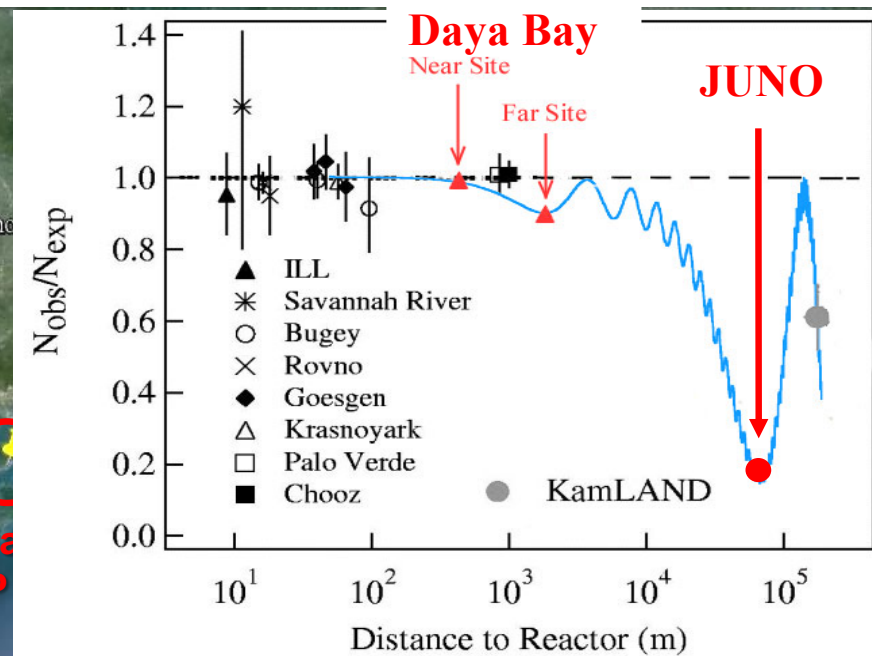
- Data taking terminated on Dec. 12, 2020
 - Ceremony broadcasted online, 1.7 M viewers
 - Detector decommissioning completed
- Data analysis still in process:
 - Final nGd results obtained: $\sin^2 2\theta_{13}$ precision $\sim 2.8\%$
 - Final nH and combined results will be released next year $\rightarrow 2.6\%$?



JUNO Experiment

- A 20 kt liquid scintillator detector at ~53 km baseline from reactors for neutrino mass hierarchy, precision determination of oscillation parameters and astrophysics

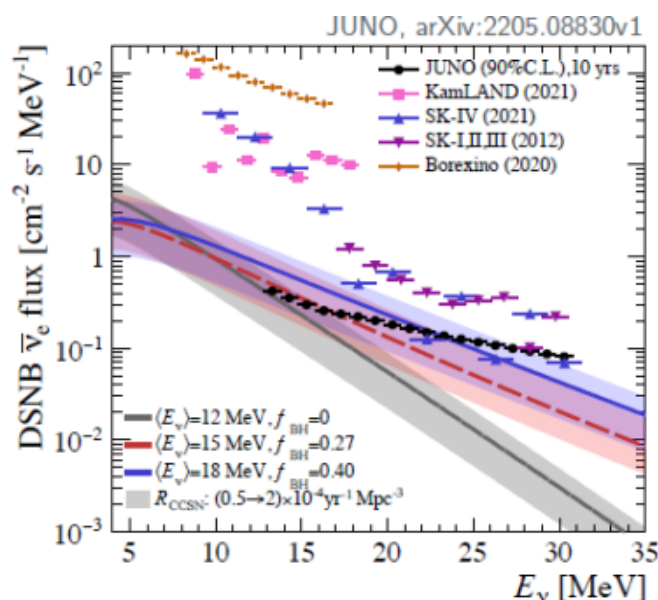
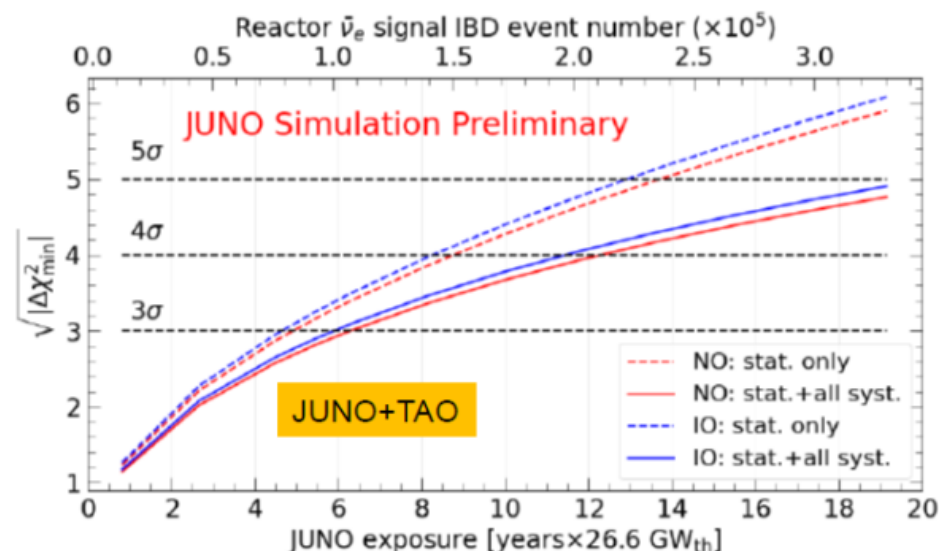
Overburden ~ 700 m



	Target mass [t]	energy resolution
JUNO	20,000	3% @ 1 MeV
Borexino	300	5% @ 1 MeV
KamLAND	1,000	6% @ 1 MeV
Daya Bay	20	8% @ 1 MeV

Physics of JUNO

- Energy resolution of $\sim 3\%$ @ 1 MeV leads to a sensitivity of NMO at 3σ @ $\sim 6 \text{ yrs} \times 26.6 \text{ GW}$
- Atmospheric neutrinos contribute another $\sim 0.7 \sim 1.4 \sigma$ @ $\sim 6 \text{ yrs}$
- Most of neutrino oscillation parameters can be improved to a **sub-percent level**
- Solar, supernova and geoneutrinos



- high stat. if burst SN ν nearby
- high prob. to discover diffused SN ν

	Current (PDG2020)	JUNO (100 d)	JUNO (6 y)
Δm^2_{31}	1.3%	0.8%	0.2%
Δm^2_{32}			
Δm^2_{21}	2.4%	1.0%	0.3%
$\sin^2\theta_{12}$	4.2%	1.9%	0.5
$\sin^2\theta_{13}$	3.2%	47.9%	12.1%

Construction of JUNO

- Civil construction mostly finished
- Components mostly produced, including a new type of high efficiency 20" MCP-PMTs
- SS structure completed, acrylic sphere bonding in progress
- PMT installation will start in a few months, LS Filling will start next year
- High energy resolution(3%@1MeV) and cleanness(10^{-17} g/g) seems realizable



JUNO-TAO: a LS detector at -50°C

- ◆ A high precise neutrino detector located at the Taishan Nuclear Power Plant, ~30m from a 4.6GW reactor core

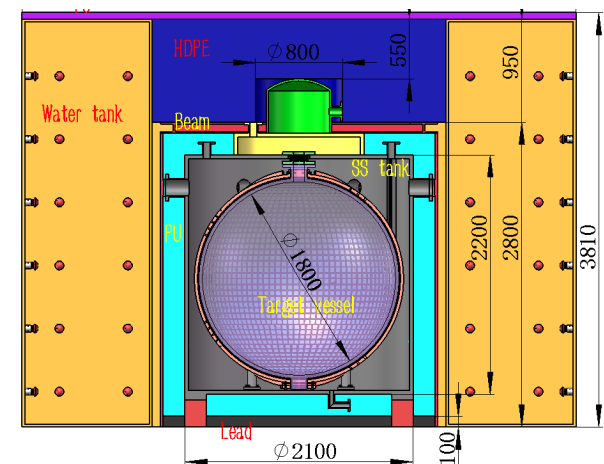
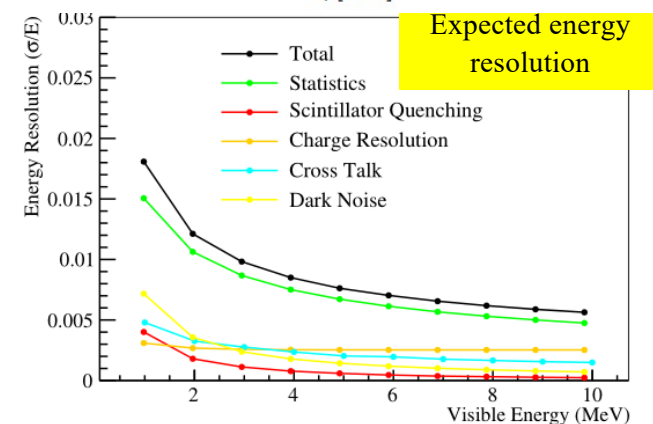
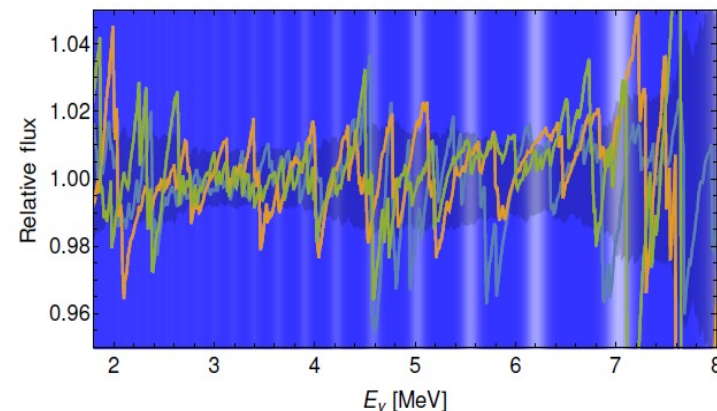
- ⇒ A reference neutrino spectrum to improve MH and constrain uncertainties(arXiv:2005.08745)
- ⇒ Sterile neutrino searches
- ⇒ Nuclear data

- ◆ Highest possible energy resolution $\sim 1.5\%/\sqrt{E}$:

- ⇒ Large area SiPM:
 - PDE > 50%, >90% coverage, 10 m²
 - 4500 p.e./MeV → × 3 JUNO;
- ⇒ Operate at -50°C to reduce SiPM dark noise by 3 orders of magnitude to 100 Hz/mm²
- ⇒ Gadolinium-doped liquid scintillator working at -50°C → a new recipe

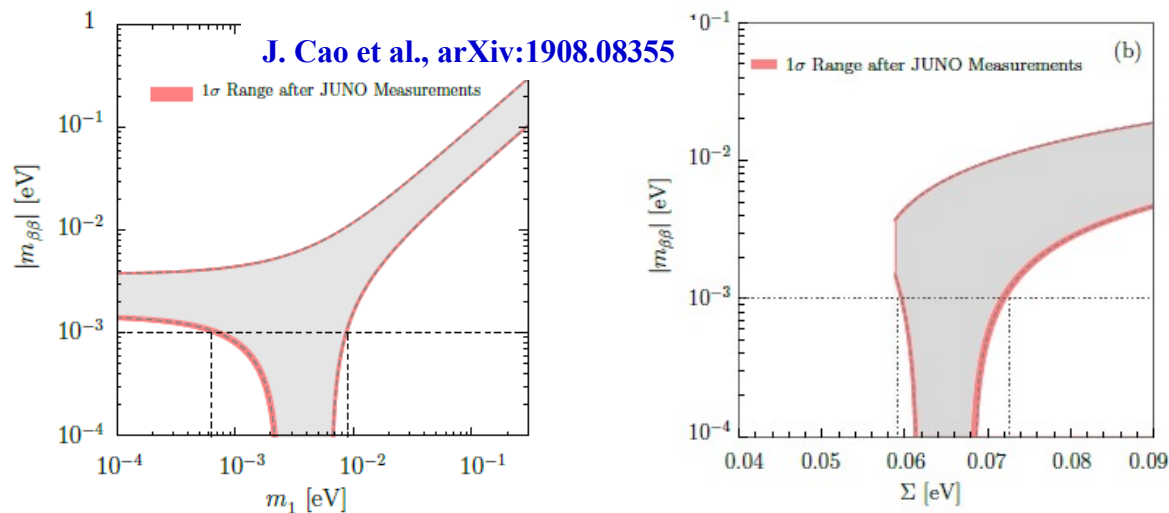
- ◆ ~2000 IBD/day with ~2% bkg

- ◆ To be operational in 2023

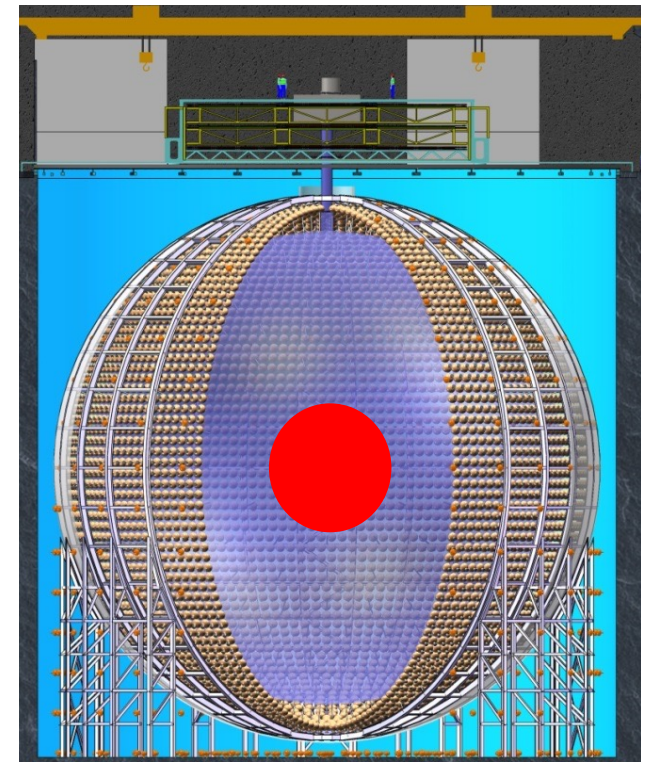


JUNO- $\beta\beta$

- In 10-20 years from now, oscillation will be mostly understood
- $0\nu\beta\beta$ decay will be the next focus point:
 - Dirac-Majorana nature and the absolute ν mass



	Isotope	Mass(t)	$\langle m_{\beta\beta} \rangle$, meV
KamLAND-Zen	^{136}Xe	0.8	36-156
EXO-200	^{136}Xe	0.2	93-286
nEXO	^{136}Xe	5	7-22
Cupid-1T	^{100}Mo	1	4-7
Legend-1000	^{76}Ge	1	10-40
SNO+	^{130}Te	8	19-46
JUNO-$\beta\beta$	^{136}Xe	50	4-12
	^{130}Te	100-200	2-6 ?



Load ^{136}Xe or ^{130}Te into the LS of JUNO: good self-shielding, resolution, etc.

Zhao et al., arXiv: 1610.07143, CPC 41 (2017) 5

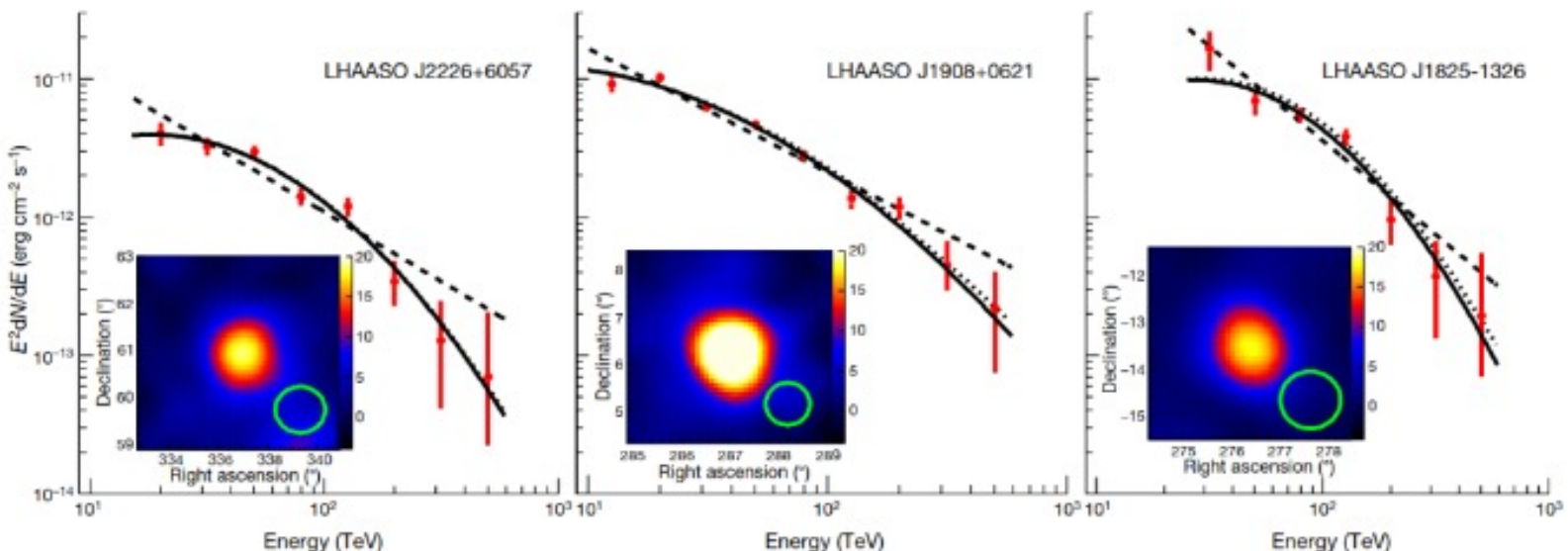
Cosmic-Rays and γ -astronomy

— Large High Altitude Air Shower Observatory(LHAASO)

- World largest air shower array(with e, μ , water Č detectors and Č telescope) for the high energy γ -astronomy and cosmic-ray physics
- Construction just completed and interesting results obtained:
 - Highest γ -rays from the Milky Way: 1.4 PeV
 - many γ -ray sources up to ~ 1 PeV identified \rightarrow PeVatrons in Milky Way
- Future:
 - Large Array of Cherenkov Telescopes (LACT)

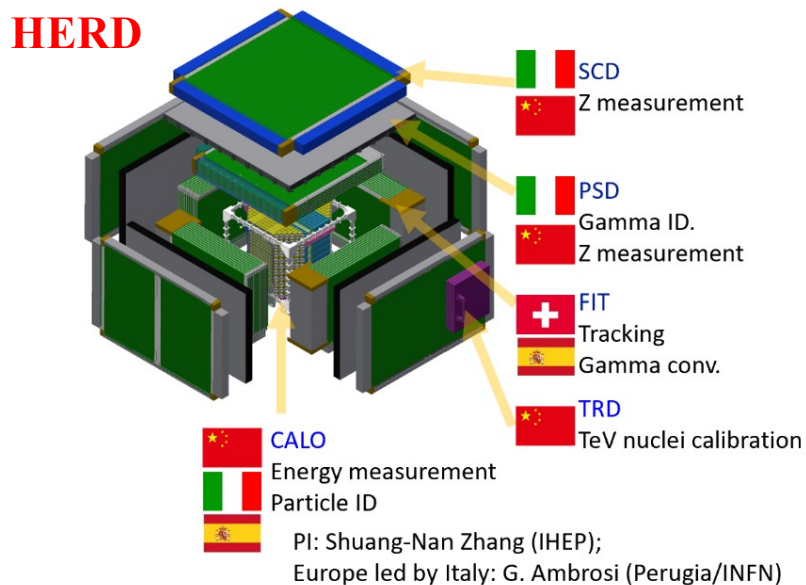


Sichuan, 4410m above the sea

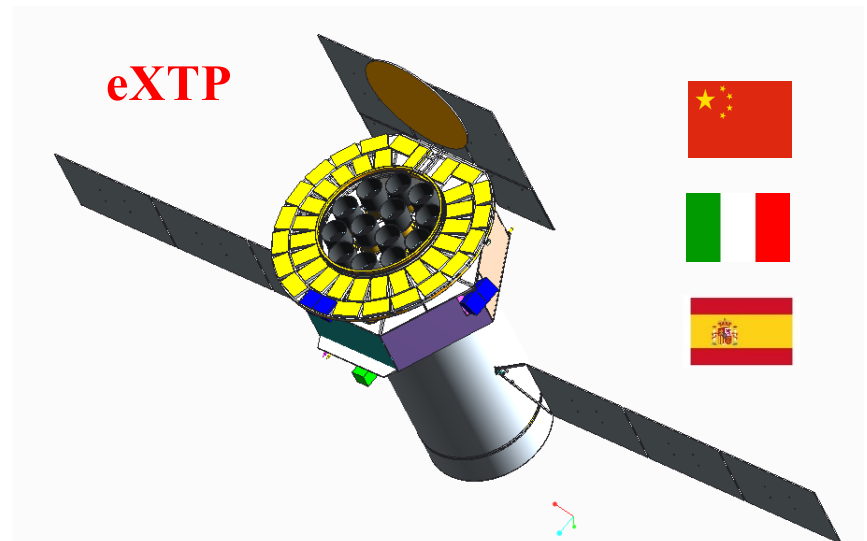


Future Space Programs

- A 3D crystal calorimeter for $\times 10$ acceptance and $\times 10$ higher energy on board of the Chinese Space Station, to be launched in ~ 2027
 - dark matter search
 - Precise cosmic ray spectrum and composition to calibrate LHAASO
 - Gamma-ray sky survey
- Large international collaboration

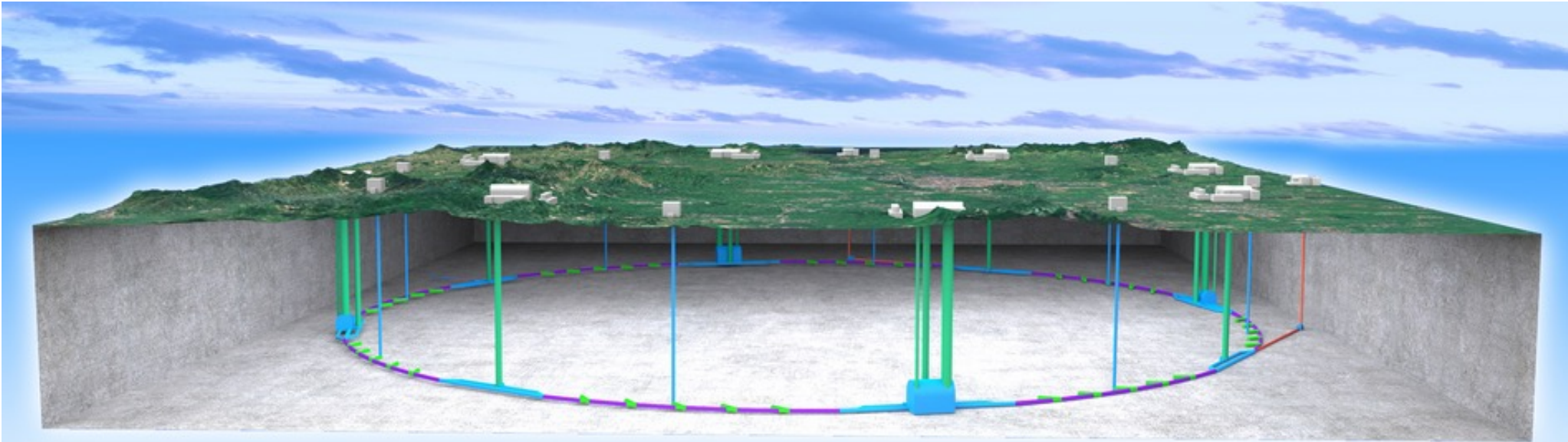


- Enhanced **X-ray Timing and Polarimetry** as the next generation x-ray satellite for
 - Neutron stars, black holes, etc to study Extreme gravity, magnetism, density, etc.
- Cutting-edge technology
 - Large eff. Area ($\sim 3.5 \text{ m}^2 @ 6 \text{ keV}$)
 - High spectral resolution ($< 180 \text{ eV} @ 6 \text{ keV}$)
 - Polarimetry
- Large international collaboration



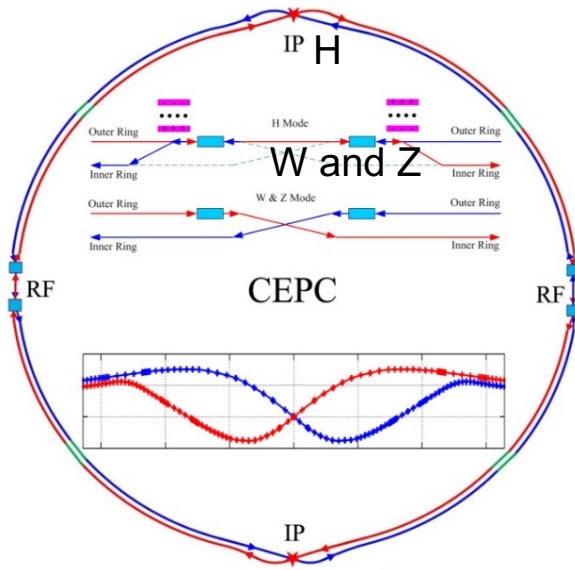
CEPC — A Higgs Factory

- The idea of a Circular e^+e^- Collider(CEPC) followed by a possible Super proton-proton collider(SPPC) was proposed in Sep. 2012, and quickly gained the momentum in IHEP and in the world
 - Looking for Hints@ e^+e^- Collider → If yes, direct search@PP collider
 - The tunnel can be re-used for pp, AA, ep colliders up to ~ 100 TeV → compatibility study needed now

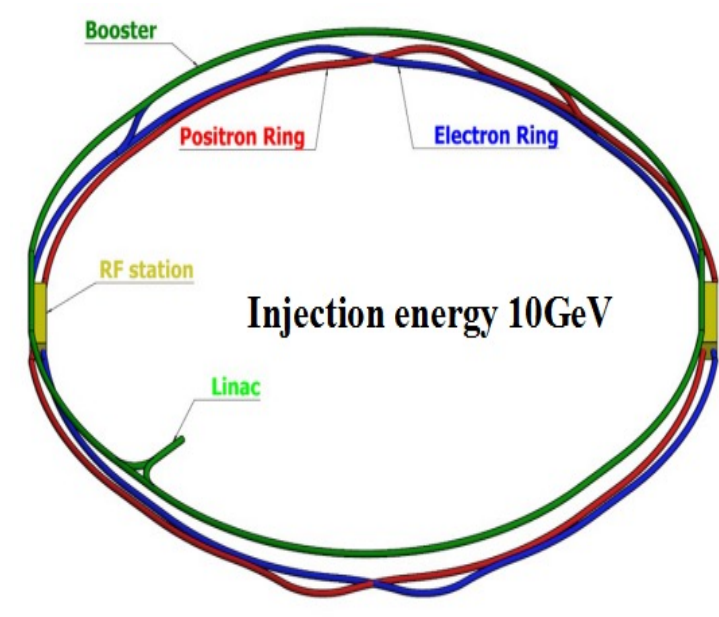


The idea was firstly reported at the Fermilab Higgs Factory workshop in Oct. 2012

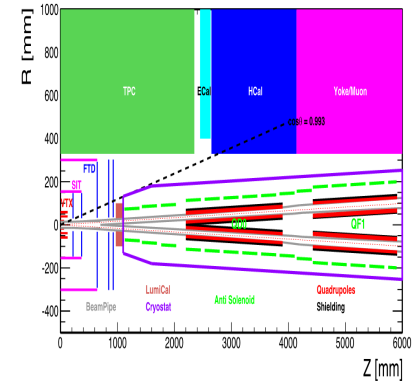
CEPC Layout



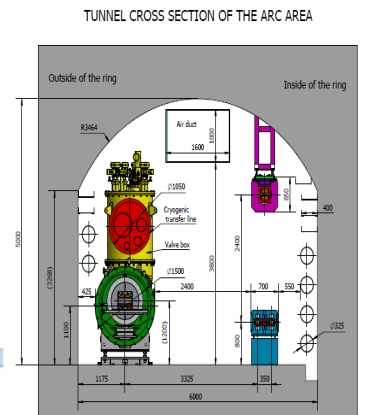
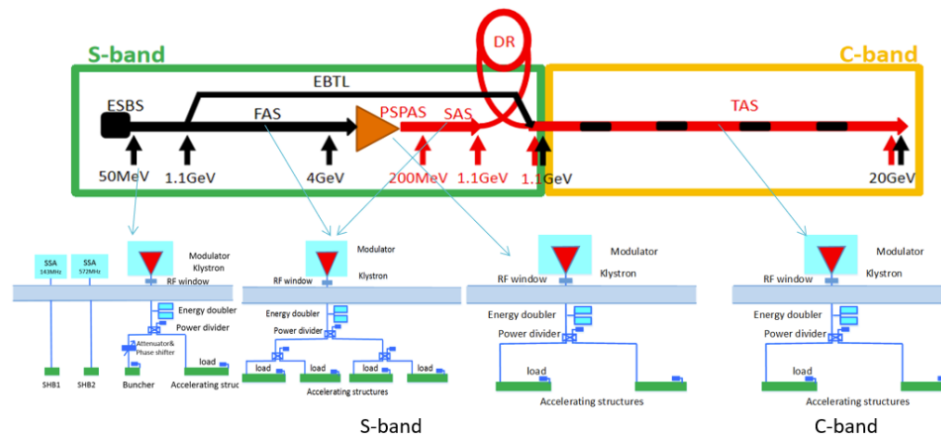
Collider ring (100km)



Booster ring (100km)



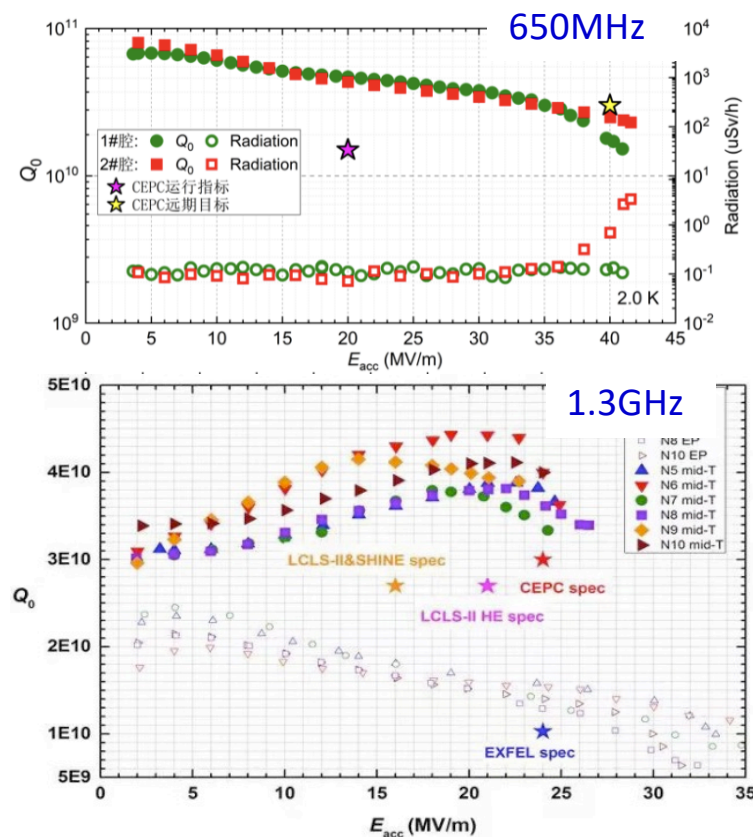
Operation mode	ZH	Z	W ⁺ W ⁻	tt
\sqrt{s} [GeV]	~240	~91.2	158-172	~360
L / IP	CDR (2018)	3	32	10
$[\times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}]$	Latest	5.0	115	16
			16	0.5



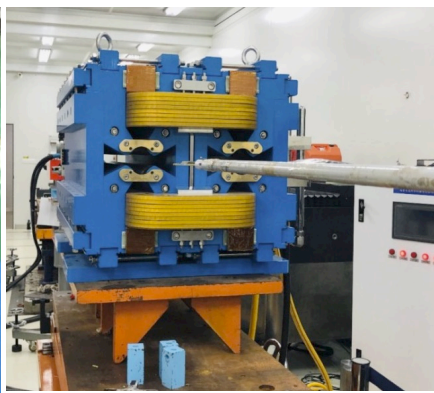
Baseline: 100 km, 30 MW; Upgradable to 50 MW, High Lumi Z, ttbar; Compatible to pp collider

Design and R&D Efforts

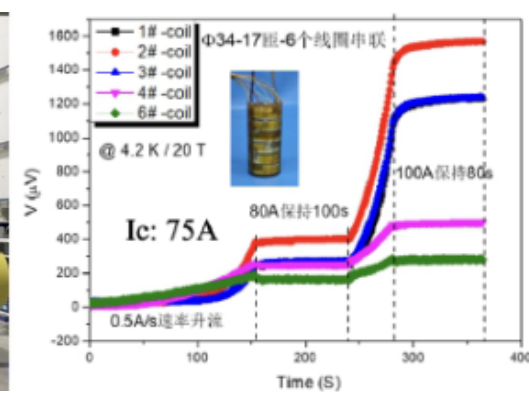
- Strong support from MoST, CAS and NSFC, at a total funding level of > 40 M \$
- CDR completed, TDR to be completed soon
- Key technology R&D:
 - SRF cavities
 - High efficiency Klystrons
 - Plasma wake-field accelerator for the injector
 - Iron-based HTc superconducting tech.
 - Magnets, vacuum pipes, beam diagnostics, polarized electron gun, positron source, ...
 - Silicon pixel chips, gas chambers, calorimeters, ...



magnets



Klystrons



IBS coils

New Detector Design and R&D

**Scint Glass/Steel
PFA HCAL**

Advantage: Higher sampling ratio for better energy resolution
Challenges: Light yield, transparency, mass production.

Solenoid Magnet (3T / 2T)

Advantage: HCAL absorbers act as the return yoke.

Challenges: thin enough magnet not to affect the jet resolution; stability

Transverse Crystal bar ECAL

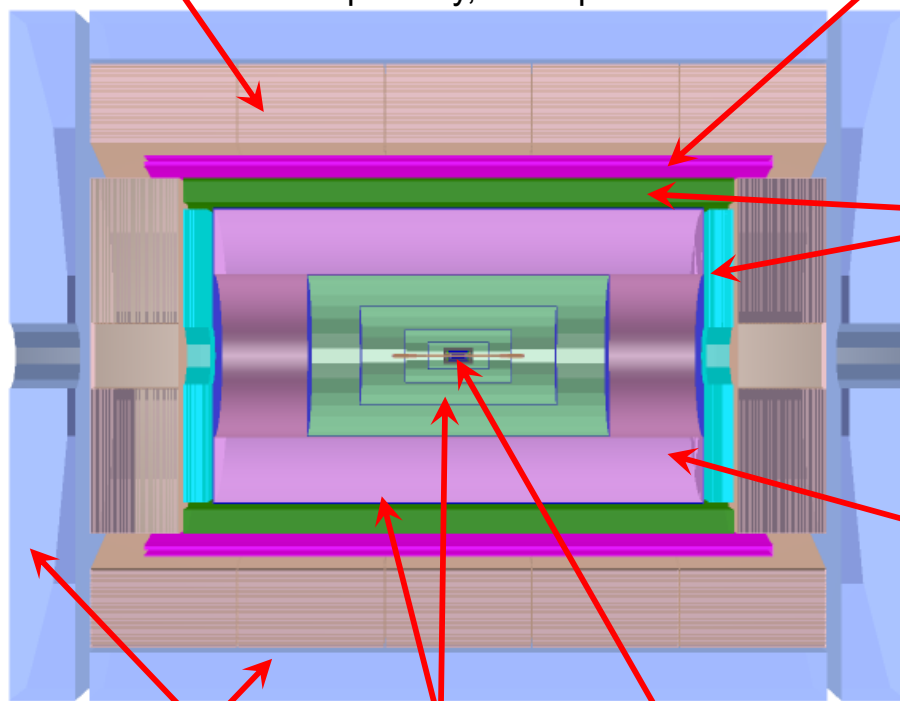
Advantage: better e/γ energy resolution, 2D readout with timing with 3D capabilities for PFA

Challenges: ambiguity of showers if too close; high energy π^0 reconstruction

A Drift chamber optimized for PID

Advantage: improve Si tracking, good PID

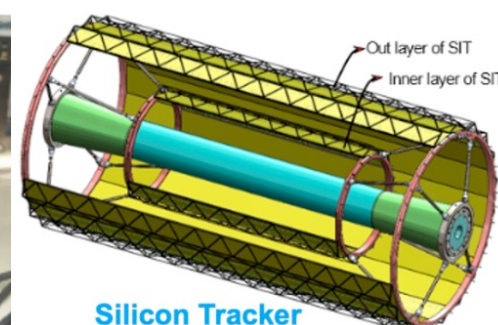
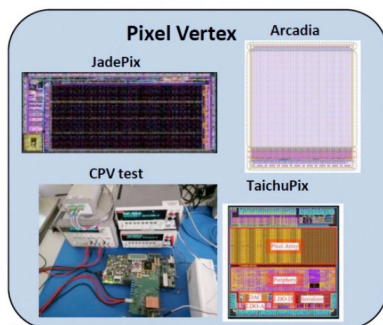
Challenges: suitable for high event rate; good dN/dx for sufficient PID power



Muon+Yoke

Si Tracker

Si Vertex



Project Status

- Continuing the design and R&D efforts in the next few years, developing the engineering design report for government approval
- Strengthening international collaborations, in particular with other Higgs factory proponents
- Actively working with CAS to prepare the proposal to MoST for the “China initiated large science projects”
- Under the guidance of CAS, developing a roadmap and an executable program of large science projects for the 15th 5-year plan
 - Evaluate proposals based on science, technology and feasibility at international contest
 - For the first time to have an International Advisory Committee to help
 - Finalize the report by mid 2023, and then approach to the NCDR with the help of CAS
- Continue to develop and build international collaborations for detectors
- Hopefully to start the civil construction in the next 5-years plan(2025-2030)

International Projects

- KEK
 - BELLEII(IHEP+Univ.s)
 - COMET(IHEP+Univ.s)
 - SuperK (Tsinghua)
- CERN & Europe
 - Prototype of the HL-LHC CCT magnet delivered to CERN, tested OK(IHEP)
 - All experiments and upgrade at LHC: ATLAS, CMS, LHCb and ALICE (many)
 - PANDA(IHEP+IMP+Univ.s)
 - Darkside(IHEP)
- US
 - EXO/nEXO(IHEP), LBNF(IHEP)
 - GlueX(IHEP)
 - AMS and its upgrade(IHEP+Shangdong+Univ.s)

Other Projects

- China Spallation Neutron Source(CSNS) in our Dongguan Campus operational since 2018 at 100 kW beam power
- Upgrade to 500 kW with 10 more beam lines will start soon
- High Energy Photon Sources(HEPS) in Huairou, north of Beijing is under construction, to be operational in 2025
 - 6 GeV, 0.036nm·rad emittance, 1260m Circumference,
 - Brilliance: $>10^{22}$ phs/s/mm²/mrad²/0.1BW

